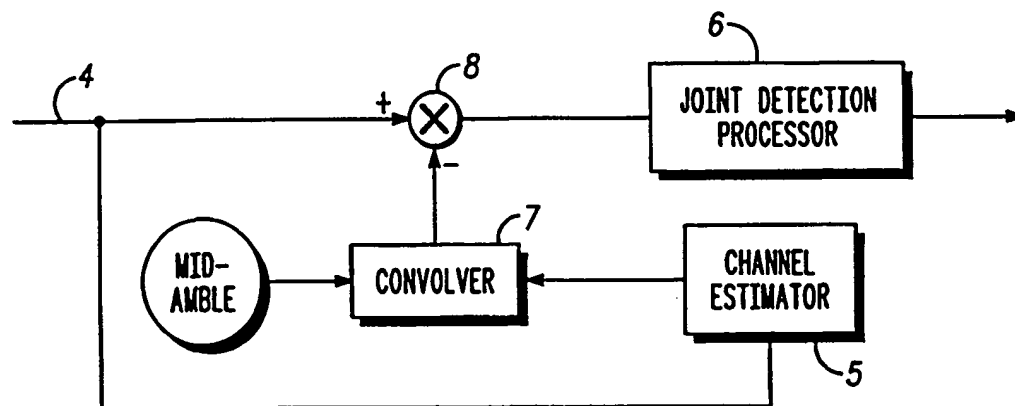




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04L 25/03, H04B 1/707, 7/005	A1	(11) International Publication Number: WO 99/52249 (43) International Publication Date: 14 October 1999 (14.10.99)
(21) International Application Number: PCT/EP99/01973 (22) International Filing Date: 22 March 1999 (22.03.99) (30) Priority Data: 9807335.6 7 April 1998 (07.04.98) GB (71) Applicant (for all designated States except US): MOTOROLA LIMITED [GB/GB]; Jays Close, Viabes Industrial Estate, Basingstoke, Hampshire RG22 4PD (GB). (72) Inventors; and (75) Inventors/Applicants (for US only): ANDERSON, Nicholas, William [GB/GB]; 26 Church Hill, Wroughton, Swindon, Wiltshire SN4 9JS (GB). O'NEILL, Rorie [GB/GB]; 25 Applewood Court, West Lea, Swindon, Wiltshire (GB). KARIMI, Reza [GB/GB]; 17 Hodds Hill, Swindon, Wiltshire SN5 5BJ (GB). (74) Agents: IBBOTSON, Harry et al.; European Intellectual Property Operations, Midpoint, Alencon Link, Basingstoke, Hampshire RG21 7PL (GB).		(81) Designated States: CN, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: A RECEIVER FOR SPREAD SPECTRUM COMMUNICATIONS SIGNALS

**(57) Abstract**

A signal processor (7,8) for a telecommunications receiver, and particularly applicable to TD-CDMA systems, provides a means for removing interference from a received data block (2) caused by the multi-path effects of the midamble portion (3) of the received signal. The known midamble sequence (3) is convolved with an estimate of the propagation channel (5) and the result is subtracted (8) from the received signal (4). The corrected signal can then be input to a conventional joint detection processor (6) for further processing.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

5 A RECEIVER FOR SPREAD SPECTRUM COMMUNICATIONS SIGNALS

This invention relates to radio receivers and particularly to radio receivers for TDMA or TD-CDMA Mobile Communications Systems.

10 In a TDMA (Time Division Multiple Access) system, a communication channel consists of a time slot in a periodic train of time intervals over the same frequency. Each period of time slots is called a frame. A given signal's energy is confined to one of these time slots. Adjacent channel interference is limited by the use of a time gate or other
15 synchronisation element in the receiver that only passes signal energy received at the proper time.

In contrast to TDMA, a CDMA (Code Division Multiple Access) system allows signals to overlap in both time and frequency. In principle, in a CDMA system the information data stream to be transmitted is impressed upon a much higher rate data stream known as
20 a signature sequence. Typically, the signature sequence data is binary, providing a bit stream. One way to generate this signature sequence is with a pseudo-noise (PN) process that appears random, but can be replicated by an authorised receiver. The information data stream and the high bit rate signature sequence stream are combined by multiplying the two bit streams together, assuming the binary values of the two bit
25 streams are represented by +1 or -1. This combination of the higher bit rate signal with the lower bit rate data stream is called coding or spreading the information data stream signal. Each information data stream or user channel is allocated a unique spreading code.

30 One CDMA technique "traditional CDMA with direct spreading", uses a signature sequence to represent one bit of information. Receiving the transmitted sequence or its complement (the transmitted binary sequence values) indicates whether the information bit is a 0 or a 1. The signature sequence usually comprises n-bits and each bit is called a "chip". The entire n-chip sequence, or its complement is referred to as a transmitted

symbol. The receiver correlates the received signal with the known signature sequence of its own signature sequence generator to produce a normalised value ranging from -1 to +1. When a large positive correlation results, a 0 is detected. When a large negative correlation results, a 1 is detected.

5

A plurality of coded information signals modulate a radio frequency carrier, for example, quadrature phase shift keying (QPSK) and are jointly received as a composite signal at a receiver. Each of the coded signals overlaps all of the other coded signals, as well as noise-related signals in both frequency and time. If the receiver is authorised, then the
10 composite signal is correlated with one of the unique codes, and the corresponding information signal can be isolated and decoded.

In a TD-CDMA (Time Division-Code Division Multiple Access) system, each time-slot within the TDMA time frame is divided into a plurality of channels which are uniquely
15 distinguished from each other by means of the CDMA process. The use of such a system gives some advantages over a communications system using either TDMA or CDMA alone.

A TD-CDMA receiver needs to be able to separate the time slots in each frame and also
20 separate the coded signals (by using a correlation process). By such means, channels can be separated at the receiver. If all the unique codes within a time slot are orthogonal, rejection of unwanted channels at the receiver is complete. However, the transmitted composite signal can become corrupted in the transmission process and in such cases, the codes arriving at the receiver are no longer orthogonal. This results in signals from
25 unwanted channels corrupting the data on the wanted channel.

This form of interference can be removed by the known process of "joint detection". In a typical joint detection receiver, the receiver is provided with all the codes and therefore able to decode all the channels within a given time slot. Further processing of the
30 channel outputs enables a better estimate of the wanted channel signal to be obtained. One known method of estimating an unknown transmitted channel symbol sequence in a joint detection receiver involves zero-forcing block-linear equalisation.

The current TD-CDMA proposal for the air interface of the third generation mobile telecommunications systems (UMTS-Universal Mobile Telecommunications Systems) requires that joint detection of multiple codes is performed by the receiving end of the link. This requires that each mobile radio channel from the one (in the case of the downlink) or multiple (in the case of the uplink) transmitters to the receiver must be estimated.

The propagation channel through which a transmitted burst passes, comprises a transmit filter, a mobile radio channel and a receiver filter. The propagation channel is of a fixed length - W chips. A burst typically comprises at least one data block of say, N symbols and a pre-defined training sequence.

Normally, the joint detection equations can be solved using propagation channel estimates and knowledge of the spreading codes used.

The signal model normally assumed is $\underline{r} = \underline{A}\underline{d}$ where \underline{r} is the received signal vector (of length $NQ+W-1$ chips) arising due to a symbol block of length N Symbols, where Q is the spreading factor. \underline{d} is the vector containing the symbol transmitted for each code and \underline{A} is the modulation matrix containing information regarding the user spreading codes and channel estimates. This is of size $(NQ+W-1) \times NK$ where K is the number of codes (or user channels).

These equations however as they stand, do not take into account the interference caused by the training sequence portion of the burst due to reflections of the transmitted signal prior to their arrival at the receiver. i.e. multi-path effects are not taken into account. The equations are not representative of the true situation for the last W-1 chips of \underline{r} when processing the first block, nor for the first W-1 chips of \underline{r} when processing the second block. This results in a performance degradation because the joint detection processing does not take the interference caused by the training sequence into account.

This invention aims to remove such interference.

The training sequences, often referred to as midamble sequences, in a typical TD-CDMA mobile communications system are known. Also known are the relevant channel
5 coefficients. By using these two facts, the interference caused by a dispersive propagation channel acting on the midamble can be removed from the datablock portions of the received signal.

Accordingly, the present invention consists of a signal processor for a receiver forming
10 part of a telecommunications system in which an information signal burst transmitted from a remote transmitter and comprising at least one data portion and a training sequence portion is received at an input of the receiver via a propagation channel, said burst being degraded in the transmission process,
wherein the signal processor includes apparatus for removing degradation from the
15 received burst incurred in the transmission process,
said apparatus comprising a convolver for convolving an estimate of the propagation channel characteristics with the training sequence of the received burst to generate a correction signal,
and a subtracter for subtracting the correction signal from the received burst to produce a
20 modified burst signal for further processing.

The further processing can comprise a joint detection processing arrangement.

The signal processor may be incorporated in the receiving circuitry of a base station
25 and/or mobile station of a mobile communications system.

An embodiment of the invention will now be described, by way of example only, with reference to the drawings of which;
Figure 1a and 1b are schematic diagrams showing the structure of a transmitted and
30 received burst, respectively, in a telecommunications system to which the invention is particularly applicable,

Figure 2 is a schematic block diagram of a receiver incorporating apparatus in accordance with the invention.

5 In Figure 1a, a transmitted TD-CDMA burst comprises a first datablock 1 comprising N data symbols and a second data block 2 comprises N symbols, the first and second datablocks 1,2 being separated by a midamble portion 3 of L chips. By virtue of the CDMA technique previously explained, a single burst comprises information associated with a plurality of communications channels.

10 A propagation channel through which each burst passes typically comprises a transmit filter (not shown), the air interface and the receiver filter (not shown) and is defined as a having a length of W chips.

15 Figure 1b shows the received burst in which part of block 1 (length W-1 chips) has shifted into the midamble time slot and part of a midamble 3 (of length W-1 chips) has shifted into the second datablock 2 timeslot. This shifting is due to reflections of the transmitted burst over the air interface being detecting at the receiver (i.e. multi-path effects).

20 The resulting inter-symbol interference caused by the midamble portion being received during the second block timeslot is removed by the apparatus incorporated in Figure 2.

Referring then to Figure 2, a telecommunications receiver, installed in a base station (not shown) and a mobile station (not shown) of a mobile telecommunications network, for
25 receiving a TD-CDMA burst on line 4 is provided with a channel estimator 5 whose output is connected to a joint detection processor 6 and to a first input of a convolver 7. A second input of the convolver 7 is provided with the known midamble sequence. An output of the convolver 7 is fed into a subtracter 8 which also receives the burst on line 4. The output of the subtracter 8 is fed to a joint detection processor 6.

30

From the received burst an estimate of the channel characteristics is made in the known manner by the channel estimator 5. This estimate is then convolved in the convolver 7

with the known midamble sequence and the result is subtracted (by the subtracter 8) from the received burst. The resulting signal is input to the joint detection processor 6 for processing in accordance with known techniques. The output of the joint detection 6 comprises estimates of the transmitted symbols for each user channel.

5

For block 1, the last $W-1$ chips contain a contribution from the midamble. This contribution is simply the convolution of the first $W-1$ chips of the midamble with the propagation channel. This convolution is performed in the convolver 7 and the interfering signal is subtracted from the last $W-1$ chips of \underline{r} . Similarly, for block 2, the interference caused by the midamble 3 is simply the convolution of the last $W-1$ chips of the midamble sequence with the propagation channel for block 2, this can be subtracted from the first $W-1$ chips of \underline{r} in order to eliminate the interference caused by the midamble 3.

15 In this manner, $2 \times (W-1)/Q$ (rounded up) symbols in each burst will have increased likelihood of being estimated correctly, thus improving performance through reduced bit error rate, or allowing for reduced transmit power to maintain the same bit error rate as was achieved without this additional processing.

20 Since the number of symbols that are adversely affected by the midamble increases with the mobile radio channel link (or the transmit/receive filter impulse response duration), so the improvement gain through the use of this method also increases. For long mobile radio channels, e.g. hilly terrain, considerable improvements in performance can be achieved.

25

Also, on the uplink, mobile users will be received with different relative delays so even if actual channel dispersion is low, it can appear as if a given user has a significant impulse response duration, i.e. the delay must be absorbed by the channel estimation process. Thus the invention improves performance in this situation also.

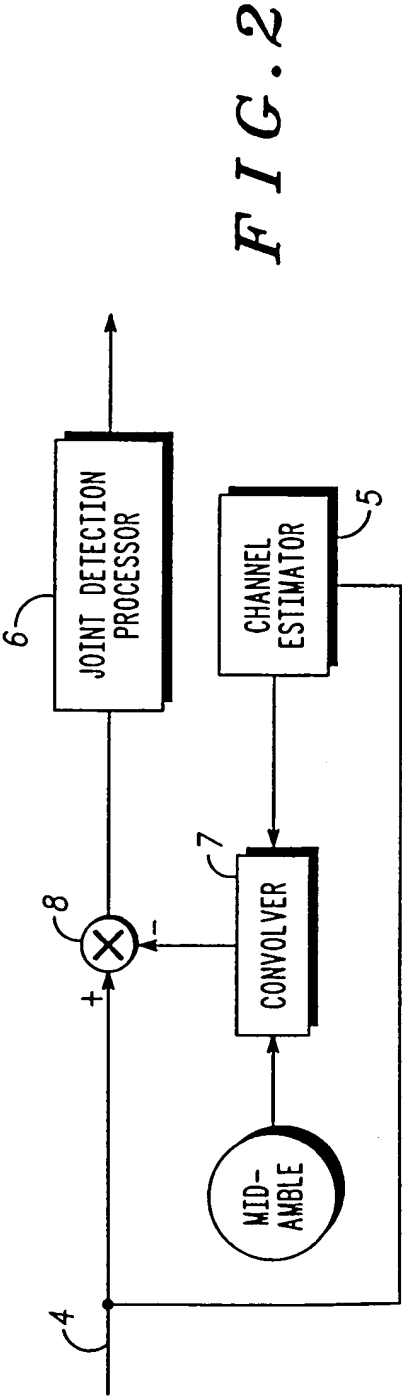
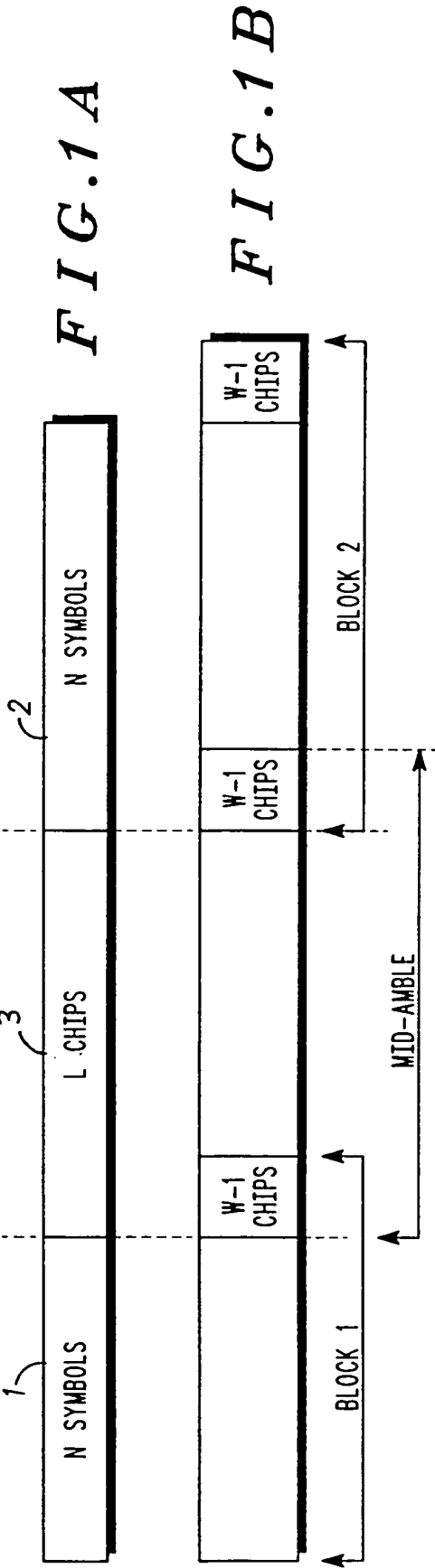
30

While this invention is most useful when applied to the TD-CDMA case, it is also applicable to TDMA systems.

CLAIMS

1. A signal processor (7/8) for a receiver forming part of a telecommunications system in which an information signal burst transmitted from a remote transmitter and comprising at least one data portion (2) and a training sequence portion (3) is received at an input of the receiver via a propagation channel, said burst being degraded in the transmission process, wherein the signal processor includes apparatus for removing degradation from the received burst incurred in the transmission process, said apparatus comprising a convolver (7) for convolving an estimate of the propagation channel's characteristics with the training sequence (3) of the received burst to generate a correction signal, and a subtracter (8) for subtracting the correction signal from the received burst to produce a modified burst signal for further processing.
2. In a telecommunications system in which an information signal burst(1, 2, 3) is transmitted from a remote transmitter to a receiver via a propagation channel, said burst comprising at least one data portion (2) and a training sequence portion (3), and wherein said burst suffers degradation in the transmission process, a method for removing said degradation including the steps of:
receiving the transmitted burst,
in the receiver, convolving an estimate of the propagation channel's characteristics with the training sequence portion to generate a correction signal,
and subtracting the correction signal from the received burst to produce a modified undegraded burst .

25



INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 99/01973

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04L25/03 H04B1/707 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 767 543 A (SIEMENS AG) 9 April 1997 (1997-04-09) abstract page 2, line 21 - line 36 page 3, line 14 - line 24 page 7, line 45 - page 8, line 22 claims 1,2 figures 1,3	1,2
A	WO 98 07243 A (NOKIA TELECOMMUNICATIONS OY ;JOKINEN HARRI (FI); RANTA PEKKA (FI);) 19 February 1998 (1998-02-19) page 2, line 12 - line 33 page 4, line 11 - line 17 figure 2	1,2

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

16 July 1999

Date of mailing of the international search report

26/07/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040. Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Lustrini, D

INTERNATIONAL SEARCH REPORT

Int l Application No

PCT/EP 99/01973

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 96 11533 A (NOKIA TELECOMMUNICATIONS OY ;NOKIA MOBILE PHONES LTD (FI); HOTTINE) 18 April 1996 (1996-04-18) page 6, line 27 - line 35 page 17, line 2 - line 23 figures 3,5 -----</p>	1,2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 99/01973

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0767543 A	09-04-1997	NONE	
WO 9807243 A	19-02-1998	FI 963203 A AU 3852397 A EP 0914724 A NO 990666 A	16-02-1998 06-03-1998 12-05-1999 12-02-1999
WO 9611533 A	18-04-1996	FI 944736 A AU 697708 B AU 3654795 A EP 0784887 A JP 10507598 T NO 971545 A	08-04-1996 15-10-1998 02-05-1996 23-07-1997 21-07-1998 04-06-1997

1/1

